CUYAHOGA VALLEY NATIONAL PARK
Programmatic Environmental Assessment for Riverbank Management
of the Cuyahoga River

Appendix B – Site/Reach Condition Assessment

Background

The Towpath Trail and Valley Railway occupy the same valley corridor as the meandering Cuyahoga River. The river channel is constrained by steep slopes and man-made confinements: several roads; bridges; the Towpath Trail; and the Valley Railway. The proximity of the Towpath Trail and Valley Railway to the Cuyahoga River and its tributaries results in instances where cultural and recreational resources are in jeopardy of being damaged or destroyed by the natural resource. Such impacts of the Cuyahoga River and its tributaries also result in potential threats to visitor and NPS staff safety. Tripping and falling hazards can develop quickly along a severely eroding bank and excessive settling due to erosion along the Valley Railway can result in track instability.

Prior to the establishment of Cuyahoga Valley National Recreation Area (CVNRA) in 1974, private and public interests constructed 38 bank stabilization measures involving 2.72 river miles. These longitudinal measures consist of riprap, concrete rubble, bedrock slabs (ledge-rock), timber walls and even automobiles. In addition, permeable timber groins were constructed in one location.

Since establishment of CVNRA, the NPS has been required to periodically stabilize segments of the Cuyahoga River to prevent the failure of the Towpath Trail and Valley Railway. Under the Riverbank Stabilization Program, 19 projects, involving 1.84 river miles, have been constructed along the riverbank adjacent to the Towpath Trail or Valley Railway, since 1992. The projects have used a variety of engineered measures that include: stacked gabion baskets, stacked gabion baskets with plantings, riprap, and a riprap toe constructed to the mean annual flood elevation with a combination of bioengineering measures above that point to the top of the repaired bank. Although these engineered measures primarily use natural materials (rock riprap, plantings, seeding) instead of manmade materials (sheetpiling or concrete retaining walls), they are reactionary in nature. Furthermore, the types of measures that can be used when the riverbank is within 20 feet of the feature, are limited in number. Under the current program there is also no means for addressing low priority sites, using less intrusive measures that could eliminate or delay the need for engineered measures later on. Some less intrusive measures that have been used at NPS and other facilities include: cabled trees, root wads, and engineered log jams. Cuyahoga Valley National Park also does not have a policy for dealing with trees threatened by erosion that are located at the top of the riverbank, or with tree debris that is conveyed by the river. Both of these conditions have been observed to aggravate riverbank erosion.

As an outgrowth of the Riverbank Stabilization Program, CVNP began a Riverbank Erosion Monitoring Program in 1997 to identify and prioritize these areas of concern, and 36 locations are currently identified. New locations are added to the list as site conditions change. Sites are prioritized as HIGH, MODERATE or LOW according to the risk (distance from the Towpath Trail or Valley Railway to the top of the riverbank), and the susceptibility to erosion (the amount

of bank lost per year along a given plane). Engineered stabilization measures are constructed to repair the riverbank at sites with either a MODERATE or HIGH priority. Cuyahoga Valley National Park currently has a number of projects that have been planned, designed and approved for construction in 2003 and 2004. These projects have undergone the requisite NEPA review and thus need to be included in the baseline condition.

Cuyahoga Valley National Park initiated an assessment and revision to their current practices of addressing riverbank erosion under the Streambank Stabilization Program in 2002. The goal of the NPS in this decision process is to select an alternative for managing the riverbank that will accomplish the objective of protecting the cultural, historic and recreational values of the Towpath Trail and Valley Railway while minimizing interference with the Cuyahoga River's natural processes. The purpose of the NEPA process is to disclose the likely impacts of the proposed action, and alternatives to that action. This process included a conditions evaluation and assessment of the Cuyahoga River from Bath Road (RM 37.55) to I-480 (RM 12.1) on October 14-16, 2002.

General Conditions

The Cuyahoga River Valley is characterized by undulating to rolling hills with a level floodplain, terraces, and steeply incised tributaries. Wide expanses of level or nearly level land predominate within the floodplains. These expanses are interrupted by sporadic sandy ridges that are the last remnants of glacial lake beaches. Soils of the valley walls and valley terraces were formed in glacial outwash gravel and sand deposits, or from slack-water deposits of silt and clay or lacustrine material.

The Cuyahoga River generally flows from south to north in CVNP, through a confined valley ranging from 500 to 4200 feet wide. The valley and river are characterized by a gentle gradient predominated by riffle/pool sequences with long intermediate runs. Valley slope and channel slope are 0.14 percent and 0.1 percent, respectively. The river exhibits an irregular meander pattern with oxbows, oxbow lakes, and scars throughout the valley. It is moderately entrenched, with a wide floodplain on the inside meander. Stream banks are predominately vegetated with both herbaceous and woody vegetation. The outside meanders, where the majority of erosion occurs, are typically vertical cut-banks with exposed soils and mature trees and herbaceous vegetation at the top. Numerous locations provide evidence of previous stabilization efforts using measures such as riprap, large rectangular stone, and flow deflection structures, which where placed prior to the NPS taking ownership. Point bars consist of sandy loam mixed with gravel (Bergmann Associates and FIScH Engineering, 2001).

A fluvial geomorphology assessment of the Cuyahoga River was conducted in 1997 (Environmental Design Group and Biohabitats, 1997). The river was classified using the Rosgen Classification System which quantifies a stream's variables, or morphologic characteristics, in varying levels of resolution from broad characterizations to site specific descriptions (Rosgen, 1993). The key variables used in the analysis include gradient, bankfull width and depth, sinuosity, valley confinement, and particle size. Bankfull refers to the discharge that fills a stable alluvial channel up to the elevation of the active floodplain (Fischenich and Allen, 2000). Sinuosity is defined as the stream length divided by the valley length. The first four variables are used to categorize the stream into one of seven major types. The last variable, particle size, is used to further define the stream type. Particle size is the median diameter of channel materials,

as sampled from the channel bed surface, between the bankfull stage and thalweg elevations. Tables B-1 and B-2 list the characteristics of the classification system.

Table B-1. Stream Classification Key Variables (Rosgen, 1993)

Channel Type	Channel Gradient	Width/Depth Ratio	Sinuosity	Entrenchment Ratio
A	4 to 10%	<12	Low (<1.2)	1 to 1.4
B	2 to 4%	>12	Moderate to high (>1.2)	1.41 to 2.2
C	<1%	>12	High (>1.4)	>2.2
D	1 to 2%	> 50	Unstable	>2.2
E	<2%	<12	Very High (>1.5)	>2.2
F	<2%	>12	Moderate to High (>1.2)	1 to 1.4
G	2 to 4%	<12	Moderate (>1.2)	1 to 1.4

Table B-2. Further Classification By Particle Size Of Bed Material (Rosgen, 1993)

Channel Type	Bed Material
1	Bedrock
2	Boulder
3	Cobble
4	Gravel
5	Sand
6	Silt

These variables were evaluated for the Cuyahoga River within CVNP. It was determined that, in general, the river exhibits characteristics of a type C5 morphology within most of CVNP, with some reaches exhibiting a type F5 morphology (Environmental Design Group and Biohabitats, 1997). Table B-3 lists typical characteristics of C5 and F5 streams.

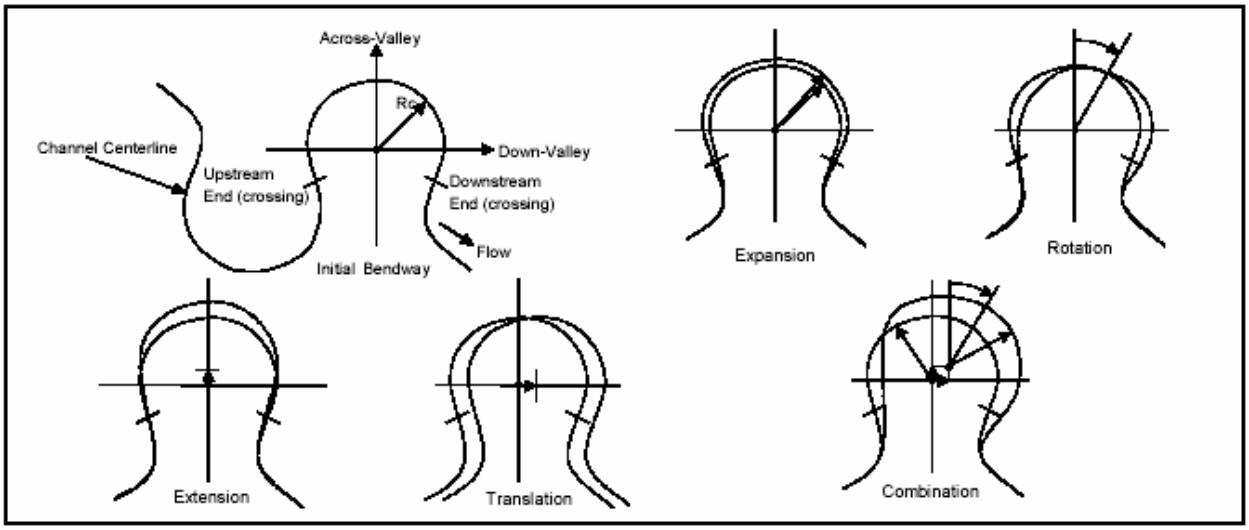
Table B-3. Characteristics Of C5 And F5 Streams (Rosgen, 1993)

Characteristic	Type C5	Type F5
Sensitivity to Disturbance (including increases to stream flow magnitude and timing and/or sediment increases)	Very High	Very High
Recovery Potential (assumes natural recovery once cause of instability is corrected)	Fair	Poor
Sediment Supply (includes suspended and bedload from channel derived sources and or from stream adjacent slopes)	Very High	Very High
Streambank Erosion Potential	High	Very High
Vegetation Controlling Influence (vegetation that influences width/depth ratio-stability)	Very High	Moderate

Table B-3 shows that the potential for bank erosion along the Cuyahoga River is high to very high. Bank failure mechanisms along the river include: erosion at the toe (the lowest part of the embankment); erosion of the upper banks; bank failures resulting from mass removal of the toe; translational failures related to seepage lenses in the bank; and rotational failures due to surcharge loads and moment forces from large trees on the banks. Of these mechanisms, erosion at the toe and translational failures of the upper bank are most prevalent (Bergmann Associates and FIScH Engineering, 2001).

The threats to the Valley Railway and Towpath Trail result primarily from the migration of channel meanders. Channel migration includes lateral channel shift (expressed in terms of distance moved perpendicular to the channel center line, per year) and downvalley migration (expressed in distance moved along the valley, per year). The migration of channel meanders can be reasonably described by four modes of movement as shown in Figure B-1.

Figure B-1. Measuring Meander Migration (Spitz et al., 2001)



Extension is across-valley migration and is easily measured at the center of the bend radius (R_c). Similarly, translation is down-valley migration and is also measured at the center of the bend radius. Expansion (or contraction) increases (or decreases) bendway radius. Rotation is a change in the orientation of the bendway with respect to the valley alignment. A change in any of these four modes of movement results in a change in the location of the outer bankline. Combinations of these modes of movement generate a wide variety of bendway shapes through time.

The National Cooperative Highway Research Program (NCHRP) is presently conducting Research Project 24-16 (scheduled for completion in mid-2003) in an effort to develop a practical methodology to predict the rate and extent of lateral and downvalley channel migration in proximity of transportation facilities. This methodology will utilize a GIS measurement tool to obtain the necessary data for both photogrammetric and regression analyses. The methodology for prediction of meander migration will concentrate on three modes of migration (extension, translation and expansion: see Figure B-1) and development of multiple regression relationships to predict channel migration in the vicinity of features of concern.

The products of NCHRP 24-16 may provide a practical means to improve the Riverbank Erosion Monitoring Program by combining aerial photography with GIS and multiple regression equations to better anticipate future threats to the Valley Railway and Towpath Trail from the Cuyahoga River. Cuyahoga Valley National Park plans to review the results of this research and will assess the benefits of incorporating any recommendations into their monitoring program.

Riverbank Stabilization Actions Prior to NPS

Prior to 1974, private and public interests constructed bank stabilization measures consisting of riprap, concrete rubble, bedrock slabs (ledge-rock), timber walls, permeable timber groins, and even automobiles. Table B-4 shows a summary of these actions by reach (as identified below under "Physical and Geomorphological Conditions Assessment"). The 2.72 miles of bank stabilization represents approximately 6.2 percent of the banks of the Cuyahoga River through CVNP.

Table B-4. **Riverbank Stabilization Prior to NPS**

Study Reach	No. of Locations	Length (ft.)
1	4	775
2	2	255
3	1	200
4	6	1335
5	4	570
6	8	5230
7	8	3868
8	5	2130
Total	**38**	**14363 (2.72 mi)**

Riverbank Stabilization Program

Previous stabilization activities on the river are numerous and widespread. A survey of the banks in October 2002 revealed that 24093 linear feet (or 10.4 percent) of the banks have existing, visible stabilization. Of this, about 9730 linear feet (or 4.2 percent of the total bankline) was stabilized by CVNP since 1992 in an effort to prevent the loss of the Valley Railway or the Towpath Trail. Table B-5 summarizes the NPS actions constructed to date.

Table B-5. Riverbank Stabilization Program Projects

Location	Station/Mile Post	Year Repaired	Length (ft.)	Method
Towpath Trail				
North of Lock #30	1100+09	1992	2060	Gabion Baskets
S.R. 303	1132+00	1992	50	Gabion Baskets
2500' South of 303	1160+00	1992	570	Gabion Baskets with Plantings
1.8 miles South of 303	1233+00	1992	240	Gabion Baskets with Plantings
4000' South of Bolanz Rd.	1340+00	1992	260	Gabion Baskets with Plantings
RM 17.7	630+00	1994	550	Gabion Baskets with Plantings
Hathaway Road	515+00	1995	500	Combination of riprap and bioengineering
Boston Store	1010+00	1996	200	Riprap
2200' South of Canal Road and Sagamore Road	677+00	1997	280	Combination of riprap and bioengineering
Stumpy Basin	1060+00	1997	400	Riprap
2400' South of Canal Road and Sagamore Road	675+00	1999	1600	Combination of riprap and bioengineering
5500' North of S.R. 82	710+00	1999	300	Combination of riprap and bioengineering
1400' South of Canal Road and Sagamore Road	650+00	1999	650	Combination of riprap and bioengineering
North of Ira Road	1380+00	2001	375	Combination of riprap and bioengineering
Valley Railway				
8000' South of S.R. 82	57.2	1993	300	Riprap
600' North of Riverview	62.8	1993	100	Riprap
2400 South of Rockside Road	63.8	1994	300	Riprap
1400' South of Fitzwater	61.2	1996	225	Riprap
3500' South of Fitzwater	60.7	2001	275	Riprap

Riverbank Monitoring Program

Cuyahoga Valley National Park began a Riverbank Erosion Monitoring Program in 1997 to identify and prioritize these areas of concern in order to protect the Towpath Trail and Valley Railway. There are currently 18 locations along the Towpath Trail and 18 locations along the Valley Railway that have been monitored biannually since 1997. New locations are added to the list as needed and locations are removed when engineered measures are constructed to repair the riverbank. Sites are prioritized as HIGH, MODERATE or LOW according to the encroachment risk (distance from the Towpath Trail or Valley Railway to the top of the riverbank), and the

susceptibility to erosion (the amount of bank lost per year along a given plane). Table B-6 outlines the criteria for classifying a site as either HIGH, MODERATE or LOW. Although the criteria provide a quantifiable basis for prioritizing these sites, a certain amount of subjectivity based on field observations, expertise, and experience determines the final rating. Due to financial constraints, engineered measures are typically constructed to repair the riverbank under the Riverbank Stabilization Program only at sites classified as either a MODERATE or HIGH priority. A low priority site may be repaired using engineered measures if it is in close proximity to another higher priority project thereby resulting in a substantial cost savings to the NPS.

Table B-6. Criteria For Prioritizing Riverbank Sites

Prioritization	Encroachment Risk	Susceptibility to Erosion
LOW	>20 feet	<0.5 ft./yr.
MODERATE	20 to10 feet	0.5 to 1.0 ft./yr.
HIGH	<10 feet	>1.0 ft./yr.

Tables B-7 and B-8 present the current monitoring status and prioritizations for sites along the river where erosion is threatening the Towpath or Railway, respectively. Average annual erosion rates are about 0.3 feet for the identified sites, and the resources of concern are, on average, about 30 feet from the top of the bank. Differences between sites designated as LOW, MODERATE, or HIGH risk are summarized in Table B-9.

In general, erosion and bank loss are associated with the outside of bendways in sinuous reaches. The mechanisms of bank loss at the sites are numerous, and the most common include erosion, impinging flow, piping, cantilever failure, translational failure, and local scour associated with tree failure. Bank loss is most severe in areas devoid of riparian vegetation, and is the lowest in areas with dense woody and herbaceous vegetation on the banks, and where bedrock is present.

Bank loss is usually a consequence of a number of the above mechanisms acting together or in sequence. For example, a common sequence of events would include erosion at the toe of a bank slowly undercutting a tree, followed by the failure of the tree and rapid local scour undercutting the adjacent bank, followed by translational failures of the upper bank. While the triggering erosion may persist for a long time and progress slowly, the following failures can occur rapidly – often resulting in the loss of tens of feet in a single event. Thus, the average annual bank loss figures presented in the tables are only applicable over a long period (at least ten years), and any of the locations identified in the tables could lose 10 feet or more of bank in a single event, and more than 20 feet in a flow season.

Projects Planned, Designed and Approved for Construction

Cuyahoga Valley National Park currently has a number of projects that have been planned, designed and approved for construction. These projects have undergone the requisite NEPA review and, thus, need to be included in the baseline condition. These projects are planned for construction in 2003 and 2004 and are shown in Table B-7.

Table B-7. Projects Planned, Designed and Approved for Construction

Location	Station/Mile Post	Length (ft.)	Method
Towpath Trail			
Hathaway & Canal Roads	515+00	400	Combination of riprap and bioengineering
400 Ft North of Hillside Road	530+00	70	Combination of riprap and bioengineering
500 Ft South of Tinkers Creek Aqueduct	573+00	400	Combination of riprap and bioengineering
3000 Ft South of Highland Road	940+00	435	Flow deflection structures in combination with riprap and bioengineering
Valley Railway			
700 Ft South of where Riverview Road crosses the Valley Railway	62.4	250	Combination of riprap toe and buried riprap windrow.

Table B-8. Riverbank Erosion Monitoring Program Status for Towpath Trail Sites

Station	River Mile	Distance From TOB To Towpath	Loss Since Last Measure-ment (Ft)	Loss Since Initial (Tenths of Ft)	Loss Per Year	Encroachment Risk Upon Resources/ Susceptibility To Bank Erosion	Overall Rating	1997 Rating	1998 Rating	Comments From January 2002
448+00	13.40	81.2	0.00	0.20	0.071	Low/Low	Low	Low	Low	
514+00	15.00	24.4	0.00	0.00	0.000	Low/Low	Low			New site established downstream of existing repairs.
515+00	15.10	18.2	0.40	0.40	0.322	Moderate/High	High		Low	High due to destruction of site
		18.8	0.00	0.00	0.000	Moderate/High			Low	
530+00	15.49	11.45	0.00	0.15	0.034	High/High	High	Moderate	Moderate	Areas upstream of monitoring site experiencing severe erosion
573+00	16.51	21.55	0.00	8.95	1.963	Moderate/High	High	Low	Low	Continued increased rate of erosion
		19	0.00	0.00	0.000	Moderate/Unknown		Low	Low	Could not locate
610+00	17.19	11.65	0.00	0.00	0.000	Moderate/Low	Low	Low	Low	
680+00	19.20	23.2	0.25	0.25	0.055	Low/Low	Low	High	High	Site repaired but monitoring station maintained.
710+00	19.50									
758+00	20.45	8.6	1.15	1.15	0.405	High/Low	Low	Low	Low	Although the encroachment is high the bank is stable
780+00	20.80									
781+00	20.88	7.6	0.10	0.10	0.088	High/Low	High	High	High	
790+00	20.99	11.80	0.15	0.15	0.033	Moderate/Moderate	High	Low	Low	Several trees undercut making increased erosion risk
		13.75	0.00	0.00	0.000	Moderate/Moderate		Low	Low	
805+00	21.18	11.60	0.30	0.30	0.106	Moderate/ Low	Low	Low	Low	Unable to locate

Table B-8. Riverbank Erosion Monitoring Program Status for Towpath Trail Sites

Station	River Mile	Distance From TOB To Towpath	Loss Since Last Measure-ment (Ft)	Loss Since Initial (Tenths of Ft)	Loss Per Year	Encroachment Risk Upon Resources/ Susceptibility To Bank Erosion	Overall Rating	1997 Rating	1998 Rating	Comments From January 2002
875+00	23.40	62.50	2.80	2.80	1.659	High/Low	Moderate			Tree washed up on the floodplain and destroyed site
		65.30	0.00	0.00	0.000	High/Low				
900+00	24.00	51.10	2.50	2.50	0.536	Low/ Moderate	Low	Low	Low	Large rotational failure changed the top of bank
940+00	24.95	12.20	0.20	1.45	0.311	High/Low	High		High	Continues to be the area of highest concern
		9.50	0.00	1.70	0.364	High/ Moderate				
1010+00	26.67	18.45	0.00	0.00	0.000	Low/Low	Moderate	High	Moderate	Downstream of repaired area
		19.75	0.95	2.95	0.632	Moderate/Moderate		High	Moderate	Upstream of repaired area
1045+00	27.40	11.00	0.15	1.25	0.268	Moderate/Low	Low	Low	Low	
		11.60	0.10	0.60	0.209	Moderate/Low		Low	Low	
1075+00	27.95	31.30	0.10	1.05	0.225	Low/Low	Low	Low	Low	
		51.95	0.00	1.10	0.236	Low/Low		Low	Low	
1100+00	28.55						Moderate			
1107+00	28.70	50.10	0.00	0.00	0.000	Low/Low	Low			
1115+00	28.76	20.50		0.00	0.000	Low/Low	Low	Low	Low	
1130+00	29.10					High/Unknown	Moderate			
1233+00	31.65	105.80		0.5	0.174	Low/Low	Low	Moderate	Moderate	

Table B-9. Riverbank Erosion Monitoring Program Status for Valley Railway Sites

Mile Post	River Mile	Distance From Water To Rail	Loss Since Last Measure-ment (Ft)	Loss Since Initial (Tenths Of Ft)	Loss Per Year	Encroachment Risk Upon Resources/ Susceptibility To Bank Erosion	Overall Rating	Previous Rating	1997 Rating	Comments From January 2002
65.73	12.3	39.60		1.80	0.00	Low / Low	Low	Moderate	Low	Could not locate site, appears stable
64.3	13.6	25.65		0.15	0.29	High / High	High	Moderate	Low	Slope too steep, cannot take measurement. Continues to slide.
		30.10	0.00	0.00	0.00	High / Low		Low	Low	High due to slide north of stakes
64.17	14.1	37.65	0.00	1.80	0.41	Low / Moderate	Low	Low	Low	
64.14	14.2	27.65	0.95	0.95	0.22	Moderate / Low		Low	Low	
63.08	15.7	41.80	0.30	0.35	0.08	Low/ Low	Low	Low	Low	
63.05	15.7	44.30		0.00		Low/ Low		Low		New Area
62.42	16.3	41.40	3.10	6.30	1.40	Low / Moderate	High	High	Low	Area is very active and has lost 3.1' in last 10 months and therefore is considered high
61.26	17.8	24.55	0.00	3.10	0.69	Moderate / Moderate	Moderate	Low	High	
61.10	18.4	34.70	0.00	2.40	0.53	Low / Moderate	High	High	High	6" tree 20' upstream undermined and ready to fall
60.86	18.7	15.50		0.00	0.00	High / Low	High	High	High	Could not locate site, appears stable
59.62	19.9	21.60	0.10	5.10	1.13	Moderate / Moderate	Moderate	High	Moderate	
59.54	20.0	26.80	0.20	0.30	0.07	Moderate / Low		Moderate	Moderate	
59.43	20.1	18.50	0.00	0.80	0.19	High / High	High	High	Moderate	Could not locate site, appears stable
59.34	20.2	23.75	0.00	4.60	1.02	Moderate/Moderate		High	Moderate	High due to continual slumping of the bank
57.94	21.8	29.60	0.00	0.00	0.00	Low/Low	Low	Low	Moderate	
57.77	21.9	21.65	0.00	2.60	0.59	Moderate/Moderate	Moderate	Moderate	Moderate	

Table B-9. Riverbank Erosion Monitoring Program Status for Valley Railway Sites

Mile Post	River Mile	Distance From Water To Rail	Loss Since Last Measure-ment (Ft)	Loss Since Initial (Tenths Of Ft)	Loss Per Year	Encroachment Risk Upon Resources/ Susceptibility To Bank Erosion	Overall Rating	Previous Rating	1997 Rating	Comments From January 2002
57.36	22.6	30.75	0.30	0.80	0.18	Low/Low	Low	Moderate	Moderate	
57.24	22.7	23.75	0.00	2.06	0.46	Moderate/Low	Moderate	Moderate	Moderate	
55.36	25.5	27.50		0.30	0.11	Moderate/Low	High	Moderate		
55.31	25.1	34.15		0.05	0.02	Low/Low	High	Low		
52.47	29.4	42.50		0.00	0.00	Low/Moderate	Moderate	Moderate	Moderate	Stakes Missing

Table B-10. Summary of Physical Conditions at Erosion Sites by Risk Category

Risk Category	# Of Sites	Average Channel Width (Ft)	Average Bank Height (Ft)	Average Slope (%)	Total Length (Ft)	Average Distance From Top of Bank To Rail/Trail	Average Bank Loss (Feet Per Year)
LOW	26	116	9.6	0.100	7905	35.5	0.15
MODERATE	12	107	10.9	0.163	4965	33.5	0.53
HIGH	19	113	12.0	0.132	3800	20.5	0.37

Physical and Geomorphological Conditions Assessment

Physical and geomorphological conditions at each site and for each study reach were assessed during a field investigation on October 14-16, 2002. For this assessment, the Cuyahoga River within CVNP was divided into eight reaches for study, as follows:

Study Reach 1 - Bath Road to Bolanz Road
Study Reach 2 - Bolanz Road to Peninsula Dam
Study Reach 3 - Peninsula Dam to 2000' downstream of Boston Mills
Study Reach 4 - Boston Mills to 1.5 miles upstream of Brecksville Dam
Study Reach 5 - 1.5 miles upstream of Brecksville Dam to Brecksville Dam
Study Reach 6 – Brecksville Dam to Tinkers Creek
Study Reach 7 - Tinkers Creek to Rockside Road
Study Reach 8 - Rockside Road to northern limit of CVNP

Physical and geomorphological conditions for the study reaches are summarized in Table B-11. Elevations for Sections 1 & 2 were taken from United States Army Corps of Engineers HEC-RAS model; elevations for sections 3-8, valley length, and river length were measured in DeLorme 3D Topo Quads; and the slope for section 5 was assumed to be zero due to the effect of the Brecksville Dam. All other data were measured in the field.

Table B-11. Summary of Physical Characteristics by Study Reach

Study Reach	River Mile		Elevation		Valley Length (ft.)	River Length (ft.)	Slope %	Slope (ft/mi)	Sinuosity
	Upst (mi)	Dnst (mi)	Upst (ft.)	Dnst (ft.)					
1	37.3	33.2	725	709	15000	21600	0.074%	3.9	1.4
2	33.2	29.05	709	684	16900	22100	0.113%	6.0	1.3
3	29.05	26.4	684	648	11300	14500	0.248%	13.1	1.3
4	26.4	22.05	648	626	14700	22700	0.097%	5.1	1.5
5	22.05	20.6	626	626	6500	7600	0.000%	0.0	1.2
6	20.6	16.4	620	610	19600	22900	0.044%	2.3	1.2
7	16.4	13.3	597.46	582.5	12200	16000	0.094%	4.9	1.3
8	13.3	12.3	582.5	582.1	5400	5500	0.007%	0.4	1.0

The physical assessment for each site included measurements of: channel width, bank height, channel slope (either site specific or the overall reach slope), and reach length. It included assessments of: channel plan form and stability, description of any existing bank protection

measures, any other pertinent information, and photographs taken from river level. Photographs are presented in Appendix D. Tables B-12 and B-13 summarize the physical and geomorphologic conditions for the Towpath Trail and Valley Railway sites respectively.

The field investigation provided a current and independent assessment of conditions at specific sites that are presently in the Riverbank Erosion Monitoring Program. It also provided a baseline against which the proposed alternatives can be evaluated with respect to their effects on geologic processes. The effects on geologic processes (or more appropriately fluvial geomorphologic processes) are organized in Table B-14 by study reach in terms of the amount of percentage of the total river bank that is "hardened" with riprap, gabions or other revetment. The source of the "hardening" (Stabilization Actions prior to NPS, Riverbank Stabilization Program actions, and Stabilization Actions Planned, Designed and Approved for construction) is also indicated.

Table B-12. Physical and Geomorphological Conditions for Towpath Trail Sites

Towpath Station	River Mile	Study Reach	Photo No.(s)	Aerial Photo Figure No.	Channel Width (Ft)	Bank Height (Ft)	Reach Slope (Gen. or Section) (%)	Reach Length (Ft)	Channel Plan Form & Stability	Existing Bank Protection Measures	Other Comments	Recommendations	River Management Assessment Condition
448+00	13.40	7	115, 116, 117	C-21	150	14	0.094	300	Sinuous and unstable	Reach is lined with slabs of Berea Sandstone 12" thick laid on the slope, and in sizes up to 5 ft x 5 ft square.	Located at outside of bend.	Continue to monitor this site, however, no repairs are recommended at this time.	A
514+00	15.20	7	515	C-20	120	10	0.094	100	Sinuous and unstable	This location is an area of flanking at the downstream end of Station 515, where there is some low quality, small diameter riprap.	Located just downstream of the repaired 515 area.	Extend the Station 515 repair area downstream another 100 feet. Provide a riprap toe to the same elevation as the 515 repair, and provide bioengineering measures above the toe.	C
610+00	17.19	6	88	C-17	120	15	0.044	225	Sinuous but stable	Some miscellaneous quarried rock. Trees on banks in good condition and not distressed.	Begins immediately downstream of Fitzwater Road and just upstream of an existing gabion basket/gabion mattress repair area. Location on outside of bend.	Continue to monitor this site, however, no repairs are recommended at this time.	A
680+00	19.20	6	81	C-14	100	5	0.044	650	Low sinuosity and stable	Designed riprap bank protection (D50=18") to top of bank.		Continue to monitor this site, however, no repairs are recommended at this time.	A
710+00	19.50	6	80	C-14	115	10	0.044	300	Low sinuosity and stable	Repaired using riprap toe + bioengineering measures above.	50 ft. extension needed to protect unraveled upstream end of protection	Construct 50 ft. of designed riprap toe with bioengineering measures above from the upstream limit of the existing repaired area.	C
758+00	20.45	6	74	C-12	110	15	0.044	630	Low sinuosity and stable	Continuous quarried rock toe (min. D50=15") and some large quarried blocks extend 2 ft. above average water level.	Bank is 15 ft. high with no leaning trees. A good stand of trees and shrubs is present.	Continue to monitor this site, however, no repairs are recommended at this time.	A
781+00	20.88	5	72, 73	C-11	125	8	0	150	Low sinuosity and stable	None.	Tree vegetation is sparse. Reach is located opposite confluence with Chippewa Cr. Two trees nearly downed at the d/s end of the reach. Water surface slope in this section of stream is flat, being controlled by the dam near SR 82.	Continue to monitor this site, however, no repairs are recommended at this time.	A
790+00	20.99	5	70, 71	C-11	110	5 to 10	0	740	Low sinuosity and stable	Some existing quarried rock (D50=12"). First 95 ft. is vegetated with grass/shrubs.	Water surface slope in this section of stream is flat, being controlled by the dam near SR 82.	Continue to monitor this site, however, no repairs are recommended at this time.	A
805+00	21.18	5	68, 69	C-11	115	5	0	280	Low sinuosity and stable	Intermittent 24" quarried rock. Some shrubby vegetation and trees on banks. Some trees are leaning towards the stream and a few bank areas have bare spots.	A 150-ft. long bare area at downstream end has no protection. Water surface slope in this section of stream is flat, being controlled by the dam near SR 82	Continue to monitor this site, however, no repairs are recommended at this time.	A

Table B-12. Physical and Geomorphological Conditions for Towpath Trail Sites

Towpath Station	River Mile	Study Reach	Photo No.(s)	Aerial Photo Figure No.	Channel Width (Ft)	Bank Height (Ft)	Reach Slope (Gen. or Section) (%)	Reach Length (Ft)	Channel Plan Form & Stability	Existing Bank Protection Measures	Other Comments	Recommendations	River Management Assessment Condition
875+00		4	59	C-9	135	8	0.097	400	Sinuous and highly unstable	Root wads and large woody debris are already present through this bend in the river.	Towpath trail is 65 ft. from edge of bank. Field at top of bank has sparse tree cover.	Augment the root wads and large woody debris and place closer to the outer bank, but do not cable the trees to the bank.	B
900+00	24.00	4	56	C-8	90	10	0.097	300	Sinuous and highly unstable	None.	Bank is well vegetated with trees. One tree slid into the river 3 years ago at this location, leaving a 40 ft. length of bank bare.	Continue to monitor this site, however, no repairs are recommended at this time.	A
1010+00	26.67	3	44, 45	C-6	150	12	0.248	140	Low sinuosity and stable	None at this location, however, 150 ft. of a full height bank repair was constructed just downstream of this location.	Location is d/s of I-271 bridge and includes 140 ft. of the Cuyahoga plus the tributary that enters near the ODOT right-of-way.	Construct designed riprap toe with bioengineering measures above from the upstream limit of an existing full bank riprap to the rt. bank of the tributary. Monitor headcutting of the tributary.	C
1045+00	27.40	3	41, 42, 43	C-5	125	10	0.248	390	Sinuous and stable	Some existing riprap (D50=24") but coverage is inconsistent. Mixed bedrock and sand/gravel substrate.	Straight, riffle section.	Continue to monitor this site, however, no repairs are recommended at this time.	A
1075+00	27.95	3	39, 40	C-4	120	6	0.248	600	Sinuous and stable	None.	Channel is bedrock controlled. Reach begins immediately d/s of RR bridge. Two 36" maples are threatened.	Continue to monitor this site, however, no repairs are recommended at this time.	A
1100+00	28.38	3	36, 37, 38	C-4	120	8	0.248	180	Sinuous and unstable	This area located on a meander cut-off channel in a location where there is no existing bank protection.	Towpath Trail is located along a meander cut-off channel.	Since the Towpath Trail is located adjacent to a meander cutoff channel that only infrequently experiences high velocities, additional bioengineering features and tree plantings are recommended.	B
1107+00	28.61	3	31, 32, 33, 34, 35	C-3	120	6	0.248	500	Sinuous and unstable	This area located on a meander cut-off channel just upstream of 300 ft. of an existing 6 ft. high stacked gabion with gabion mattress repair. The stacked gabions are founded on bedrock.	Towpath Trail is located along a meander cut-off channel.	Since the Towpath Trail is located adjacent to a meander cutoff channel that only infrequently experiences high velocities, additional bioengineering features and tree plantings are recommended.	B
1115+00	28.76	3	30	C-3	105	6	0.26	300	Sinuous and unstable	Quarried rock to 3 ft. above water level.	Upstream end marked by large 2 bole sycamore. Upstream end lacks riprap. Bar located on opposite side of river.	Extend new riprap toe from upstream end of existing quarried rock.	C
1130+00	29.05	2	26, 27	C-3	100	6	0.37	160	Straight and stable	Intermittent quarried rock and ledgerock and well established trees and shrubs.	Reach begins 13 ft. downstream of downstream end of Rt. 303 bridge pier.	Continue to monitor this site, however, no repairs are recommended at this time.	A

Table B-12. Physical and Geomorphological Conditions for Towpath Trail Sites

Towpath Station	River Mile	Study Reach	Photo No.(s)	Aerial Photo Figure No.	Channel Width (Ft)	Bank Height (Ft)	Reach Slope (Gen. or Section) (%)	Reach Length (Ft)	Channel Plan Form & Stability	Existing Bank Protection Measures	Other Comments	Recommendations	River Management Assessment Condition
1233+00	31.65	2	17, 18, 19, 20, 21	C-1	120	8	0.113	120	Sinuous and highly unstable	250 feet of stacked gabion baskets with plantings and gabion mattress toe. Gabion baskets in good condition, appear upright. Gabion mattresses in fair condition with some separation between adjacent sections and some undermining. Some D50=8" riprap has been placed at upstream end of the gabion walls, however, this repair is beginning to be flanked.	Monitoring stake 2.5 ft. from edge of bank. Farm field upstream of the site is mowed by NPS.	Extend new riprap toe from upstream end of gabion wall. Monitor gabion mattress sections. Monitor tributary and confluence at downstream of gabions.	C

Table B-13. Physical and Geomorphological Conditions for Valley Railway Sites.

Railroad Mile Post	River Mile	Study Reach	Photo No.(s)	Aerial Photo Figure No.	Channel Width (Ft)	Bank Height (Ft)	Reach Slope (Gen. Or Section) (%)	Reach Length (Ft)	Channel Plan Form & Stability	Existing Bank Protection Measures	Other Comments	Recommendations	River Management Assessment Condition
65.73	12.3	8	118, 119		90	10	0.007	1000	Straight, stable	None.	Banks are 1H:1V or steeper. Located in a straight channel reach. Reach ends at I-480.	Continue to monitor this site, however, no repairs are recommended at this time.	A
64.3	13.6	7	112, 113	C-21	140	see report	0.094	270	Sinuous and highly unstable	None. There is 150 ft. of existing bank protection downstream of the end of this reach. Reach ends at existing culvert outlet.	Steep slope, moderate velocity.	Construct repairs as recommended in the previous Bergmann/FIScH report.	D
64.14 to 64.17	14.23	7	110, 111	C-21	155	15	0.094	500	Sinuous and highly unstable	Negligible. Moderate vegetation on banks.	Extend protection to fallen tree.	Continue to monitor this site, however, no repairs are recommended at this time.	A
63.05 to 63.08	15.73	7	95, 96	C-19	120	10	0.094	350	Sinuous but stable	None. Banks have dense shrubby vegetation and some trees.	Located at outside of bend. Top of bank is 45 ft. from Valley Railway.	Since top of bank is a significant distance from the Valley Railway, provide additional deep rooted trees and woody debris to the area. Monitor the riverbank and if necessary, make a more permanent repair if the additional vegetation and woody debris fails to arrest the riverbank erosion.	B
62.6	16.12	7	93, 94	C-18	120	8	0.094	540	Straight, stable	None. Banks have some shrubby vegetation.	Channel banks are sloped 2H:1V. Channel is straight.	Continue to monitor this site, however, no repairs are recommended at this time.	A
62.42	16.3	7	91, 92	C-18	120	16	0.094	500	Sinuous and highly unstable	There is approximately 40 ft. of existing bank protection in place. From that point downstream and upstream, the coverage is sparse.	Banks are a sand/silt/clay mix. As a result of the site visit, this location has been planned, designed and approved for construction as an emergency repair.	Approximately 250 ft. of emergency repairs are needed along the edge of streambank upstream of the existing riprap. The first portion of the ripap would be constructed as a berm against the Valley Railway embankment, wide enough to provide a sufficient volume for a launched riprap toe. The second portion of the riprap would be extended along the toe of the existing RR embankment in a buried windrow, rather than following the bank line. The stone volume in the buried windrow would also be designed for the anticipated maximum scour depth.	D
61.26	17.8	6	85, 86	C-16	100	5	0.044	325	Sinuous and unstable	Riprap (D50=18") to 3 ft. above average water level.	The 225 ft. of existing riprap repair was constructed in 1996.	Beginning at a point 20 ft. downstream of the upstream end of existing riprap, extend riprap 50 ft. upstream adjacent to RR embankment. Repair small slump 20 ft. from end of existing riprap.	C

Table B-13. Physical and Geomorphological Conditions for Valley Railway Sites.

Railroad Mile Post	River Mile	Study Reach	Photo No.(s)	Aerial Photo Figure No.	Channel Width (Ft)	Bank Height (Ft)	Reach Slope (Gen. Or Section) (%)	Reach Length (Ft)	Channel Plan Form & Stability	Existing Bank Protection Measures	Other Comments	Recommendations	River Management Assessment Condition
61.1	18.43	6	83	C-15	75	15	0.044	450	Sinuous and unstable.	None.	The few large trees are undermined and leaning towards the river. Bank recession has progressed significantly but top of bank is 35 ft. from tracks.	Augment the existing vegetation with addition of deep rooted trees and shrubs, and utilize existing tree debris to protect the bank.	B
60.86	18.67	6	No Photo		100	15	0.044	1150	Sinuous and unstable	Quarried rock of avg. D50=18" and conc. blocks to 1.5 ft, above avg. water level. Toe is stable.	Shrubby vegetation above with few trees.	Continue to monitor this site, however, no repairs are recommended at this time.	A
60.7	18.83	6	82	C-15	100	15	0.044	240	Sinuous and unstable	Designed riprap repair (D50=24") to top of bank is performing well.	Some vegetation has begun to grow between the riprap.	Continue to monitor this site, however, no repairs are recommended at this time.	A
59.34 to 60.0	20.23 to 19.7	6	77, 78, 79	C-13	100	12	0.044	3500	Low sinuosity and stable	Quarried slab rock (D50=18" and higher) placed on 1H:1V slope to 3 ft. above avg. water level has stabilized this reach.	150 ft. long bare area at downstream end with no protection.	Repair 150 ft. long bare area at downstream end of this reach that presently has no protection with a designed riprap toe and bioengineering measures.	C
57.94	21.75	5	66, 67	C-10	90	5	0	100	Sinuous and highly unstable	None	Located at junction of two branches. Erosion increases from u/s to d/s as branch flow recombines with main channel. Banks are < 2H:1V.	Continue to monitor this site, however, no repairs are recommended at this time.	A
57.77	21.9	5	64, 65	C-10	60	4	0	240	Sinuous and highly unstable	Some miscellaneous quarried rock, but very intermittent.	Two 10" sycamores are threatened. Channel is anabranched at this location.	Continue to monitor this site, however, no repairs are recommended at this time.	A
57.36	22.64	4	62, 63	C-9	120	10	0.097	420	Sinuous and highly unstable	Existing riprap toe with some tree vegetation above. Riprap is stable and not being flanked.	River is parallel to the Valley Railway at this location. There is room to augment the existing vegetation.	Augment the existing vegetation with addition of deep rooted trees and shrubs to protect the banks.	B
57.24	22.7	4	60, 61	C-9	120	10	0.097	320	Sinuous and highly unstable	An early designed riprap (D50=18-24"). The upstream end of the repair is not presently being flanked by the River.	River at low flow approaches the Valley Railway at 90 degree angle. The point bar upstream of this reach that existed in 1992 has been cut off.	Augment the existing vegetation with addition of deep rooted trees and shrubs, and utilize existing tree debris to protect the portion of bank upstream of the upstream end of the repair.	B
55.31 to 55.36	24.58	4	47	C-7	120	6	0.65	540	Sinuous and highly unstable	100 ft. of quarried rock of various D50 has been placed along a portion of this reach; however, another 300 ft. of bank downstream of the quarried rock and 140 ft. upstream is lacking any appreciable bank protection.	River at low flow approaches the Valley Railway at 90 degree angle. The point bar at this bend has narrowed over the past 40 years and a channel cut-off has begun to form.	Extend existing bank protection upstream 140 ft. Along the Valley Railway. Continue to monitor this site, and construct bank protection along the portion of bank downstream of the existing bank protection if necessary.	C
52.47	29.4	2	24, 25	C-2	105	30	0.25	100	Low sinuosity and stable	Riprap toe (D50=18") to 3ft. above water elevation.	Located in a pool section between riffles. Bank is well vegetated above the top of riprap.	Continue to monitor this site, however, no repairs are recommended at this time.	A

Table B-14. Riverbank "Hardening" (in Feet)

Study Reach	Construct-ed Prior to CVNRA	Construct-ed by CVNP	Approved & Designed by CVNP	Total	Percent Harden-ing (%)
1	775	635	0	1410	3.3
2	255	1080	0	1335	3.0
3	200	2660	0	2860	9.9
4	1335	300	435	2070	4.6
5	570	0	0	570	6.2
6	5230	4155	400	9785	21.4
7	3868	900	720	5488	17.2
8	2130	0	0	2130	19.4
Total	14363	9730	1555	25648	9.6

Aquatic Habitat Conditions Assessment

Environmental conditions at each site and for each study reach were assessed during a field investigation on October 14-16, 2002. A rapid assessment procedure based on the EPA's Rapid Bioassessment Protocol was used to characterize each site and reach. A scale of 0 – 20 was used for the rating of each factor, with 0 representing the lowest environmental quality and 20 representing the highest attainable quality for the Cuyahoga System. Descriptions of the parameters and their relevance follows. A set of decision criteria for rating is given for each parameter, using criteria as shown in Table B-15.

1. Streambank Epifaunal Substrate/Available Overbank Cover: This includes the relative quantity and variety of natural structures in the stream, such as fallen trees, logs, and branches, large rocks, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna. A wide variety and/or abundance of submerged structures in the stream provides the fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, fish diversity decreases, and the potential for recovery following disturbance decreases. Snags and submerged logs are among the most productive habitat structure for macro-invertebrate colonization in low-gradient streams.

2. Instream Substrate Characterization: Evaluates the type and condition of bottom substrates found in the reach. Firmer sediment types (e.g., cobbles, gravel) support a wider variety of organisms than a substrate dominated by sands and silts or silts and clays. In addition, reaches that have a uniform substrate will support far fewer types of organisms than a stream that has a variety of substrate types. Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) are covered by or sunken into the silt, sand, or clays of the stream bottom. Generally, as rocks become embedded, the surface area available to macro-invertebrates and fish (shelter, spawning, and egg incubation) is decreased.

3. Morphological Diversity of Channel and Flow: Diversity is a way to measure the heterogeneity of a stream. Riffles are a source of high-quality habitat and diverse fauna; therefore, an increased frequency of riffle occurrence greatly enhances the diversity of the stream community. For areas where distinct riffles are uncommon, a measure of meandering or

sinuosity helps define diversity. A high degree of sinuosity provides for diverse habitat and fauna. A diversity of depths and velocities protects the stream from excessive erosion during flooding and provides refugia for benthic invertebrates and fish. Natural conditions include reaches of moderately shifting channels and bends and stable reaches that do not exhibit progressive changes in slope, shape, or dimensions. Patterns of velocity and depth are included; the best reaches will have all four patterns present: (1) slow-deep, (2) slow-shallow, (3) fast-deep, and (4) fast-shallow.

4. Bank Vegetative Diversity and Condition Above Bankfull: Measures the amount of the stream bank that is covered by vegetation. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients and contaminants by the plants, the control of in-stream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macro-invertebrates than are banks without vegetative protection or those stabilized with uniform concrete or riprap. This parameter is made more effective by defining the natural vegetation for the region and stream type (i.e., shrubs, trees, etc.).

5. Channel Stability (Base Level): This category addresses the stability of the channel profile in terms of the normal stage of evolution channels undergo in response to urbanization. Channels that are actively headcutting (level 2), widening (level 3), or depositional (level 4) generally have degraded habitats when compared to naturally stable (level 1) or stable incised (level 5) channels. Of the three degraded conditions, level 2 stream segments generally offer the best habitat because they tend to have coarser substrates, greater pool depths and velocities, and more diversity, although the life of these features may be limited. Level 4 streams tend to have the worst habitat conditions, but are generally on the way to recovery.

6. Bank Stability: Measures whether the stream banks are eroded (or have the potential for erosion). Some erosion is necessary in a system to sustain the dynamic processes that create new habitats. However, excess erosion can eliminate existing quality habitat, adversely impact water quality, and contribute to embeddedness.

7. Riparian Vegetative Zone Width: Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank. The presence of minor paths and walkways in an otherwise undisturbed riparian zone was judged to be inconsequential to destruction of the riparian zone.

8. Riparian Management Potential: Measures the need and attractiveness of preserving existing riparian habitat in a reach or of implementing management measures to restore or improve riparian habitat. Reaches with appreciable buffer widths and the potential for high quality riparian zones can accommodate natural levels of stream instability without adverse impacts, and these reaches are given the highest scores.

Table B-15. Criteria for Rapid Environmental Assessment

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Streambank Epifaunal Substrate/ Available Overbank Cover	Greater than 50% of SRH and IRH habitat on existing banks; presence of bars, snags, cut banks, gravel or other stable bank habitat at bankfull stage to allow full colonization potential.	SRH and IRH habitat on 5 to 50% of existing banks; mix of stable streambank habitat but not all types; well-suited for full colonization potential; adequate habitat for maintenance of populations.	Less than 5% useable SRH and IRH habitat; some mix of stable streambank habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 5% useable SRH and IRH habitat; lack of instream habitat diversity is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2. Instream Substrate Characterization	Mixture of substrate materials, with gravel and cobbles prevalent; sand deposits are firm; several shoals and gravel bars; embeddedness minimal.	Mixture of sand and gravel; sands subject to shifting at moderate flows; some shoals and gravel bars; submerged vegetation present; coarse material only slightly embedded.	Primarily sands and silts; few shoals or gravel bars; little submerged vegetation; coarse material highly embedded.	Shifting fine sands, silts and clays; no shoals or gravel bars; no submerged vegetation; embeddedness not relevant.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3. Morphological Diversity and Flow Conditions	Occurrence of riffles and pools relatively frequent; no tranquil runs; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key; all 4 velocity/depth patterns present.	Occurrence of riffles and pools or sharp bends frequent, but some tranquil runs present; distance between riffles divided by the width of the stream is between 7 to 15. Only 3 of 4 velocity/depth patterns present.	Occasional riffle or bend; tranquil runs > 25% of reach; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. Only 1 to 3 velocity/depth patterns present.	Generally all tranquil runs; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. Dominated by one velocity/depth pattern.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
4. Bank Vegetative Diversity and Condition Above Bankfull	More than 90% of the streambank surfaces covered by native vegetation, including both deciduous and evergreen trees, understory shrubs, and sedges; vegetative disruption minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent.	50-70% of the streambank surfaces covered by vegetation; at least two classes of vegetation present; disruption obvious; patches of bare soil or closely cropped vegetation common.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed in many locations.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Table B-15. Criteria for Rapid Environmental Assessment (Continued)

Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
5. Channel Stability (Base Level)	Naturally stable; evidence of incision or bank failure absent or minimal; limited potential for future problems; CEM Level 1 or 5.	Stabilized; Grade control present and evidence of incision or bank failure absent or minimal; some potential for future problems; CEM Level 1, 4, or 5.	Moderately unstable; some entrenchment and/or impending entrenchment; long-term stability questionable; impending bank instability.	Unstable; entrenched; active headcuts; impending or active bank failures.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
6. Bank Stability	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems; <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over; 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
7. Riparian Vegetative Zone Width	Width of riparian zone >100 feet for at least 90% of bankline; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone exceeds 20 feet for at least 90% of bank length; human activities have impacted zone for less than 10% of banks.	Width of riparian zone less than 20 feet for 10 to 50% of bank; human activities have impacted zone for more than 10% of banks.	Width of riparian zone less than 20 feet for at least 50% of bank; little or no riparian vegetation due to human activities for at least 10% of banks.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
8. Riparian Management Potential	Existing riparian habitat high; preservation of habitat likely with minimal management; affords opportunities for demonstrations and improvements.	Existing riparian habitat only slightly degraded; preservation and/or improvement likely with moderate management effort.	Existing riparian habitat somewhat degraded; preservation and/or improvement possible but would require significant management effort.	Existing riparian habitat degraded; preservation not desirable; improvement not likely or would require significant and costly management effort.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Table B-16 presents the assessment results for each site. Table B-17 presents the average assessment scores for the study sites based upon the hazard ranking (LOW, MODERATE, or HIGH), and Figure B-2 shows the scores organized by study reach. In general, sites identified as having a LOW hazard index exhibit a higher overall environmental score than those with a HIGH hazard rating. And, in general, the upstream reaches exhibit a higher overall environmental score than do the lower reaches within CVNP. This assessment provides a baseline against which the proposed alternatives can be evaluated with respect to aquatic habitat.

Table B-16. Environmental Assessment Scores by Site

Station/ Mile Post	River Mile	Cover	Substrate	Morph. Diversity	Veg	Channel Stability	Bank Stability	Riparian Width	Mgt. Potential
65.73	12.3	17	1	1	17	17	16	8	7
448+00	13.4	10	14	16	11	9	14	5	7
64.3	13.6	6	9	12	14	13	13	4	6
64.17	14.1	12	14	16	16	14	13	12	12
64.14	14.2	12	14	16	16	14	13	12	12
515+00	15.1	6	9	10	9	10	7	4	4
530+00	15.49	13	10	12	9	12	12	7	8
63.08	15.7	7	4	3	4	15	8	16	17
63.05	15.7	7	4	3	4	15	8	16	17
62.8	15.9	5	5	4	14	14	11	5	5
62.42	16.3	4	12	12	2	4	2	3	9
573+00	16.51	12	10	7	7	10	6	5	8
610+00	17.19	14	9	10	9	11	10	4	5
61.1	18.4	7	7	7	7	13	9	3	3
60.86	18.7	3	7	6	4	15	17	3	3
710+00	19.5	5	10	10	15	15	18	5	7
59.62	19.9	13	10	10	11	15	13	9	10
59.54	20	13	10	10	11	15	13	9	10
59.43	20.1	13	10	8	14	15	16	9	10
59.34	20.2	13	10	8	14	15	16	9	10
780+00	20.8	10	10	12	14	15	15	5	15
781+00	20.88	9	9	4	12	12	12	17	17
790+00	20.99	13	8	4	12	12	11	17	17
805+00	21.18	11	9	4	12	12	13	17	17
57.94	21.8	13	4	6	8	9	12	9	7
57.77	21.9	16	14	9	13	9	15	6	4
57.24	22.7	2	4	4	3	10	13	2	2
875+00	23.4	11	6	7	3	9	4	15	15
890+00	23.8	2	5	6	2	10	4	4	17
900+00	24	12	4	4	8	10	9	15	15
940+00	24.95	7	9	9	4	8	5	4	14
55.31	25.1	11	12	9	5	8	6	5	7
55.36	25.5	2	3	4	5	10	8	1	16
1010+00	26.67	7	10	10	8	15	10	9	9
1045+00	27.4	8	11	15	14	14	13	10	9
1075+00	27.95	10	9	10	10	12	9	18	17
1100+00	28.55	12	13	15	10	6	4	18	17
1107+00	28.70	10	5	5	3	18	17	18	16
1115+00	28.76	13	13	14	12	12	12	18	16
1130+00	29.1	10	12	13	8	14	15	10	7

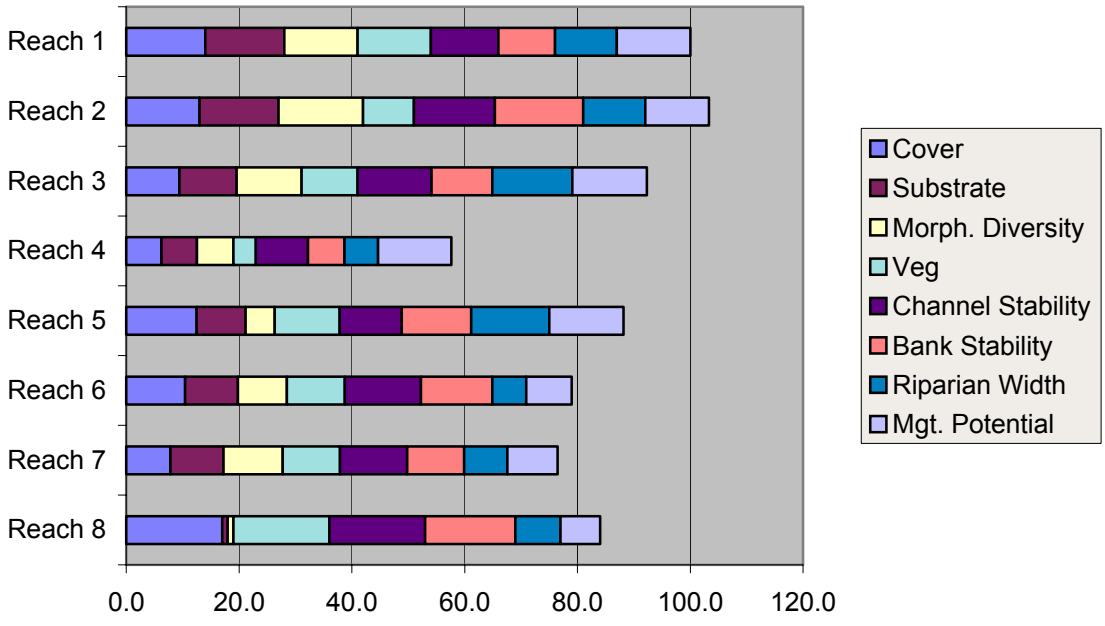
Table B-16. Environmental Assessment Scores by Site

Station/ Mile Post	River Mile	Cover	Substrate	Morph. Diversity	Veg	Channel Stability	Bank Stability	Riparian Width	Mgt. Potential
52.47	29.4	15	15	17	9	16	16	15	15
1233+00	31.65	14	15	15	10	13	16	8	12

Table B-17. Average Environmental Assessment Scores by Hazard Category

	Cover	Substrate	Morphology	Veg	Channel Stability	Bank Stability	Riparian Width	Mgt. Potential
LOW	10.4	8.6	9.3	10.7	13.0	12.0	11.6	12.1
MODERATE	9.0	9.8	10.0	7.7	12.3	10.6	8.6	10.6
HIGH	8.6	8.9	8.1	8.6	11.1	9.6	6.6	9.5

Figure B-2. Assessment Scores by Study Reach



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